The finding life emergency of senior citizen at home using human behavior model

Yasuyuki Shimada*, Tsutomu Matsumoto*, Shigeyasu Kawaji1**

** Kumamoto National College of Technology*
2659-2 Suya Nishigoshi Kikuchi Kumamoto, Japan
(E-mail: {shimada, matumoto}@ec.knct.ac.jp)

*** Graduate School of Science and Technology, Kumamoto University*
39-1 2 Kurokami Kumamoto, Japan

Abstract

As the population of persons over the age of sixty-five is rapidly growing, the population of solitary senior person living at own home is growing in Japan. This situation has caused the social issue of how supports their healthy life. There have been some projects related to improve their quality of life and support their healthy life. Unfortunately mostly they focus the method of measuring vital signal and observing behavior. Nobody reports how utilize the measured data.

Aim of our project is how find emergency of the aged people at home. As emergency is big different from regular life behavior, we have to recognize it.

We propose concept of the human behavior model and show the some types human behavior knowledge constructed by observed human behavior. This idea is based on human having habitual life. And we discuss the possibility of finding emergency using knowledge and observed data.

1. Introduction

Some research projects for improving quality of life of senior citizen have been proceeded based on sensing behavior of a senior person. Ohta reported that monitoring system gathers behavior data using infrared light sensor. His report focuses (1) visualization of moving among rooms at home (2) total movement distance and which sensor reacts to observed person moving (3) time duration of staying in a room. He does not describe how utilize corrected data for improving QOL and supporting health care. Tanikawa has also reported a monitoring system as similar as Ohta's way. Tanikawa explained that the finding method of the observed person's whereabouts can be obtained by a very simple statistics.

Hiramatsu reported the gathering data of time of turning on/off consumer electronics equipment. In his report no turning off equipment for many hours is recognized as an emergency. Disadvantages of his method are not to deal with the differences among individuals, to provide judgment low accuracy and to transfer each data from each sensor by telephone line. With Inada's report, he also talks portable equipment for correcting vital sign. He does not explain to utilize the method of gathered data in order to improve QOL.

These reports focus only the way of measuring human behavior at home. Furthermore they do not propose any behavior human model for forecasting behavior and do not use any knowledge to forecast. That is, observing a senior citizen behavior must enable the system to find some problem of their life and inform it to family doctor, their family and/or nursing staff.

We have developed the multi agent system that cares senior citizens over twenty-four hours. This multi agent system consists of sensor agent, interface agent, collaboration agent and knowledge management agent. Sensor interface agent talks capturing their behavior at home. When the agent system finds issue of client, knowledge management agent informs collaboration agent. And collaboration agent lets interface agent sends a message to physician, nursing staff or family.

We describe how a sensor agent finds issues of client as part of above mentioned multi agent system in this paper so far. We introduce a human behavior model and propose a reasoning algorithm for finding off regular life with behavior knowledge derived from corrected data and sensor data.

2. Modeling of Human Behavior

In this chapter we describe a human behavior model, a representation of human behavior knowledge and a method of finding irregular human behavior with knowledge.

2.1 Analyzing human behavior at home

People have individual life habit as after getting up we wash face and take a shower and have breakfast. We seldom change this sequence even if a time lag happens. Of course we sometimes carry out plural actions at same time like multi process in computer system. This human behavior can be structured as shown in Figure1. That is, the model is expressed by the horizontal axis being time and the vertical axis being kind of action. We call it "Human Behavior Model". Each cell has information of execution or not E means execution and $\bar{E}$ means no execution in Figure 2. For instance suppose that action A is "watching TV" and action C is "Toilet", Figure 2 shows that a person starts watching TV at the time 1 and goes to toilet at the time 2 and finish watching TV and toilet.

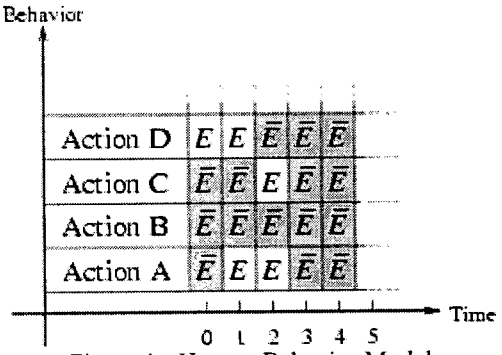

Figure 1 : Human Behavior Model

2.2 Knowledge representation

Observed data of human behavior at the time can be expressed as follows. m is a total number of action.

$$S = \{S_i \mid 0,1\}, \quad (1)$$
where, $i = 0,1,\Lambda\ , m-1$.

To construct human behavior knowledge from observed data, we numerically expressed the observed data f_k with action of sort S_i times weight W_i. This is expressed following equation.

$$f_k = \sum_{i=0}^{m-1} W_i S_i . \quad (2)$$

Also, the human behavior knowledge F can be expressed the result numerically observed data.

$$F = \frac{1}{N}\sum_{i=1}^{N} f(k,i), \quad (3)$$
where, $k = 0,1,\Lambda\ , \frac{24\times 60}{T} - 1$.

Sampling interval is T minutes. N means a number of days for observation. We can construct a day of the week model, monthly model and seasonal model with expanded this method.

Table 1:List of actions

Action	Subject
S_6	Room light
S_5	Toilet
S_4	TV set
S_3	Desk light1
S_2	Bath room light
S_1	Desk light3
S_0	Desk light2

2.2 The day of the week model and its knowledge

It is obviously that one unit of the human behavior is a day. We call it ``human behavior minimum unit". And this minimum unit becomes a element of a week. Furthermore this minimum unit is different according to the day of the week. For example many people gets to bed at night on before holiday much later than weekday night.

Therefore, The day behavior knowledge of the week can be developed by arithmetic mean of the daily-observed data according to the day of the week.

2.2.1 Monthly model and its knowledge

It is also obviously that human behavior of summer season is different from human behavior of winter season. For example in winter season people turns on the light of the room much earlier than summer season. Behavior on Sunday in summer season is different from it in winter season.

Therefore we can define two types knowledge. One is that monthly weekday knowledge which is constructed by observed data of weekdays. The other one is that monthly holiday knowledge that constructed by observed data of Sunday, Saturday, holiday and the day before holiday

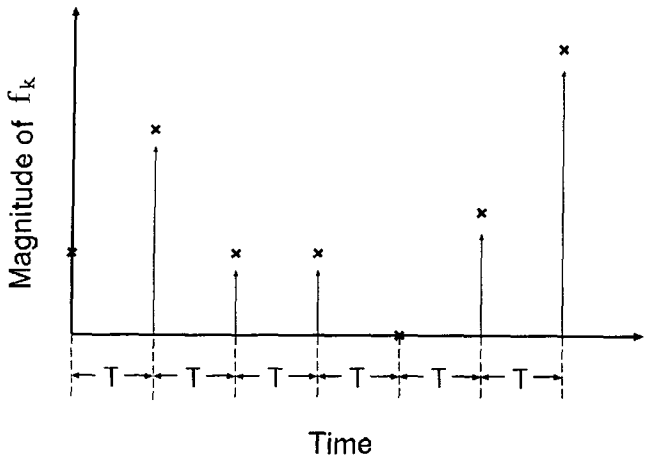

Figure 2:General Idea of human behavior knowledge

Both knowledges can be developed by the same way, the arithmetic mean. In addition, monthly knowledge consists of weekly weekday knowledge and weekend knowledge.

3. Processing Flow

Figure 3 shows the processing flow of the constructing knowledge at above mentioned. The sensor data is first processed at constructing daily knowledge part expression (3). The result goes into the day of the week knowledge part and monthly knowledge part.

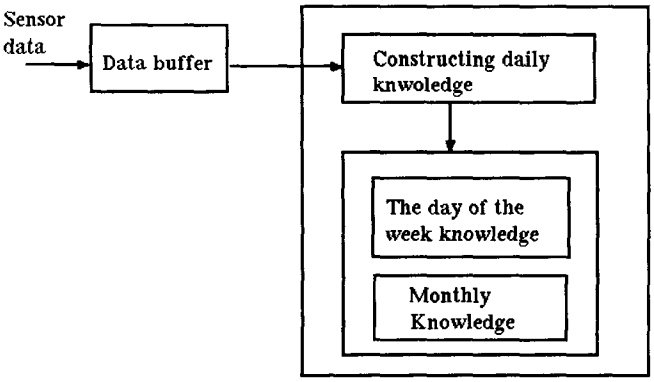

Figure 3:Software configuration of detecting regular life

4. Experiments and Discussion

4.1 Experiments

We measured behavior of a person at home for a few months. Namely $N=7$. Action to be measured is to turn on/off consumer electronic equipment. The sampling interval of sensing T is chosen as 5 minutes. The elements of S are shown in Table 1. In this case m equals to 8. Here, W_i in the expression (2) is given as 2^i. Subject is a male of sixties age. Figure 5 of subject shows the knowledge constructed by observed behavior based on expression (3).

4.2 Experimental results

The four figures are shown in Figure 4 - Figure 8. Figure 4 and Figure 5 are for October. Figure 6 is for September. Figure 7 and 8 are for August. Subject is sixties and a Professor at University. He actives at late night. Four figures show a peak about 2am. These figures show that

(1) Human has done habitual life.

(2)Behavior knowledge can be constructed by proposed our idea.

5. Application

In this chapter we discuss the possibility of finding the abnormal behavior from habitual daily behavior using knowledge and observed data.

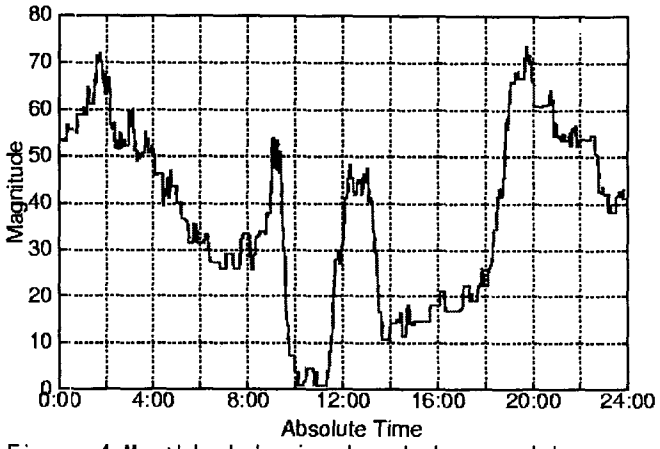

Figure 4:Monthly behavior knowledge, weekdays (October)

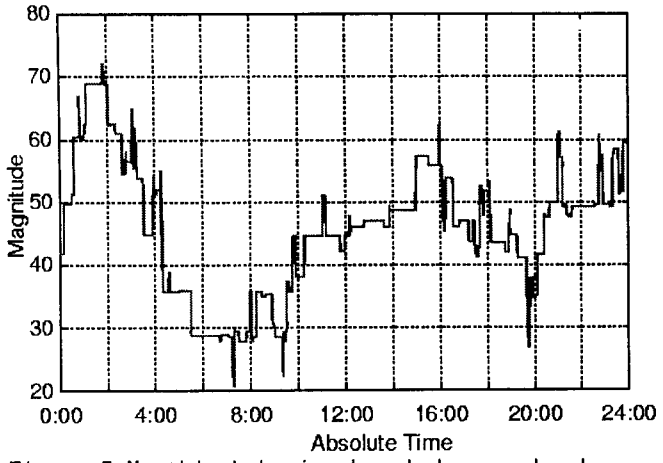

Figure 5:Monthly behavior knowledge, weekends (October)

5.1 Finding regularity of human behavior

To find the similarity between life activity of the day and life habit leads discovery of life problem. Accordingly this is to calculate correlation coefficient between observed behavior f data and behavior knowledge F. Let the observed human behavior data to be f_c which is expressed the result numerically by the same way as expression (2) using last L points. We derive the expression for calculating a correlation coefficient as follows.

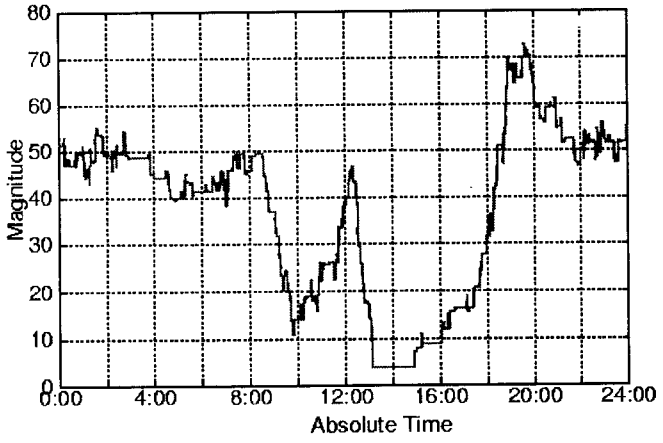

Figure 6:Monthly behavior knowledge, weekday (September)

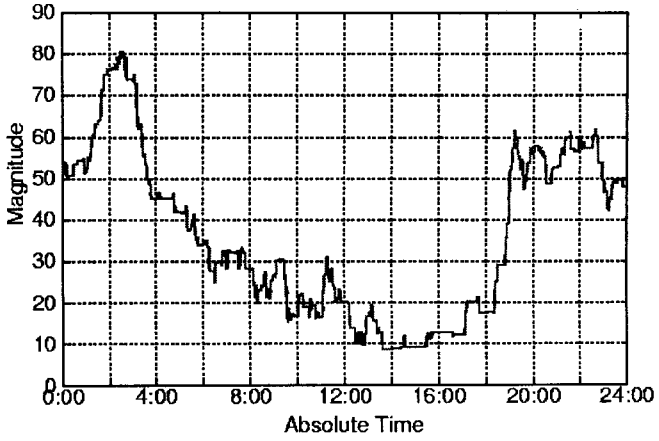

Figure 7:Monthly behavior knowledge, weekday (August)

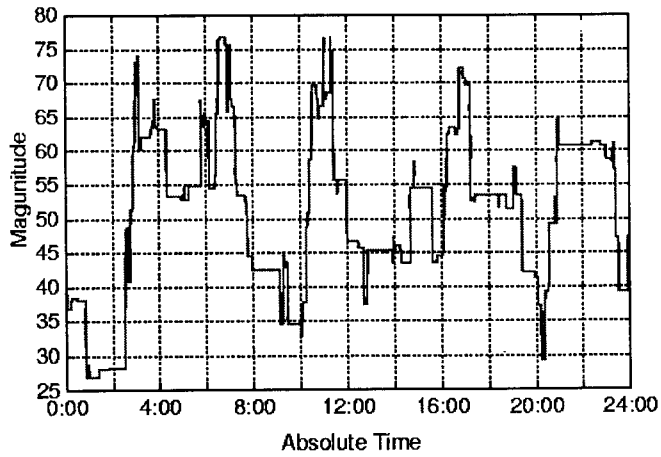

Figure 8:Monthly behavior knowledge, weekday (August)

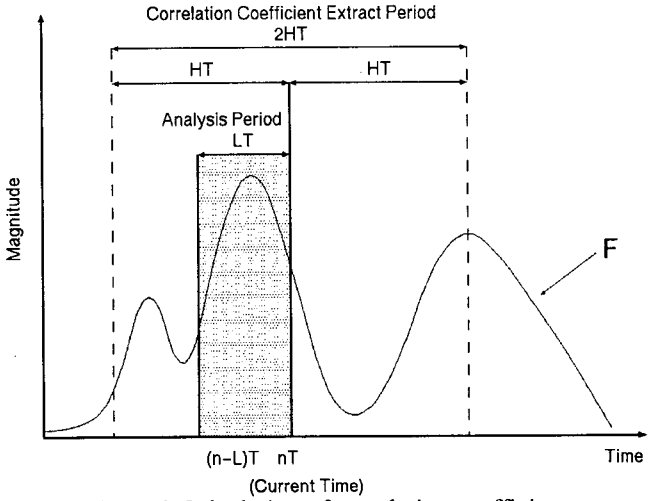

Figure 9:Calculation of correlation coefficient

5.2 Life signal

The differential of observed behavior data means life signal. This is an obvious fact. This process can be easily carried out from observed data. The human behavior knowledge can be modified using his/her results.

5.3 Data mining

Mostly people spend life according to individual habit. But sometime they break it. For instance, watching TV program until late night, coming back at home late night from party etc. In such case if next day is Sunday or holiday, people take normal sleeping time and get up late morning. At this case human behavior is different from regular life. But they have no problem. Therefore we should extract some higher knowledge from behavior knowledge.

For example, average sleeping time can be extract from knowledge. So we find time interval duration time length of no life signal on the condition that it is night.

5.4 Some results

Figure 10 is one-day behavior measured data on October. Correlation between this data and weekly knowledge (Figure 4) is shown in Figure 11. Calculation coefficient is carried out with *L=120* and *H=1200*. *Time = 0* in Fig. 11 is a center point at processing. That is; this graph shows correlation at noon. As subject has no problem, correlation coefficient is very high score at noon.

Let us suppose that subject has some problem. Figure 12 is measured data on one weekend day. Conditions for calculation are *L=120* and *H=1200*. Figure 13 shows correlation coefficient between Figure 12 and Figure 4. The figure 13 shows very low score at noon. Correlation coefficient in a few hours before noon is also low score. Behavior of subject is different from his habitual life. In other words, subject can is considered to have some problem.

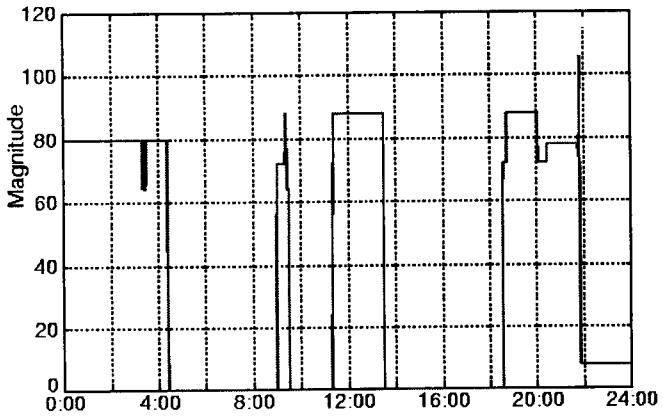

Figure 10:Measured data

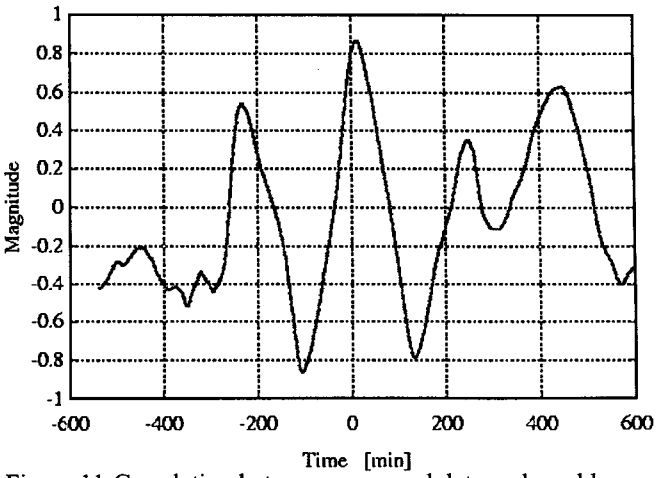

Figure 11:Correlation between measured data and weekly knowledge

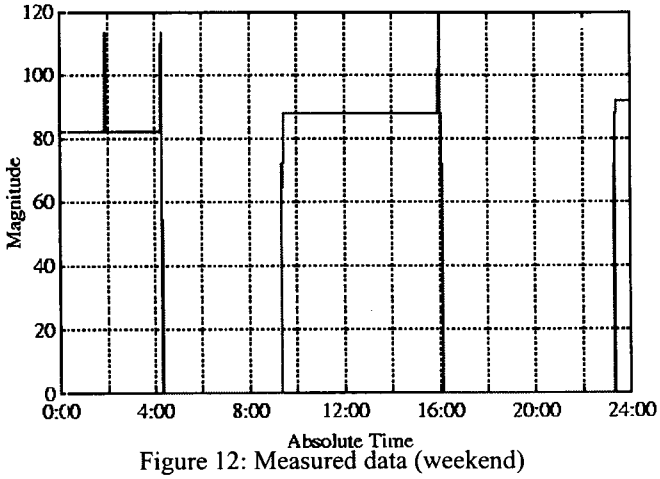

Figure 12: Measured data (weekend)

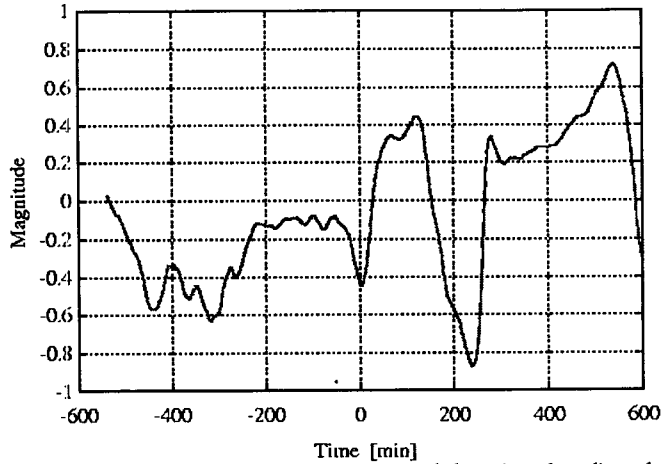

Figure 13:Correlation between measured data (weekend) and weekly data

6. Conclusion

We proposed the human behavior model and constructing the human behavior knowledge. Experimental results show that human behavior knowledge can be constructed by our proposed idea. We show that correlation between observed behavior data and knowledge is a very useful tool to find emergency. Unfortunately any graph of life reaction is not shown. To obtain a life reaction is very easy as differential calculus of observed data. We may talk how to use the life reaction with extracted life style from behavior knowledge at presentation. It is still future works.

We believe that our proposed idea must become a useful tool for finding emergency in aged people at home. Because this method can be expanded to other sensor data, for example moving a room, changing TV channel.

References

[1] Shigeru OHTA : "Health Monitoring System for the Aged", Information, Processing Society of Japan Magazine, Vol.41 No.6 pp.639-6n43 (2000).

[2] Tanikawa Tomohiro et al : "In-house Movement Monitoring System for the Aged Living Alone", 19th JCMI, pp270-271 (1999)

[3] Yoshio Hiramatsu, Motohiko Otani, Yatsuda Sinohara, : "Development of monitoring system for every day life of aged people using non-contact current sensor", The proceeding of 19th JCMI pp.272-273 (1999)

[4] Hiroshi Inada, Hiroyuki Horio, Kazuo Nakazawa, Kiyomu Ishikawa : "A Study on Development of a Home Health Care Support Information System", Proceeding of the 9th World Congress on Medical Informatics (MEDINFO 98), pp.269-271 (1998)

[5] Tsutomu Matsumoto, Shigeyasu Kawaji, Weiming Shen, Douglas H. Norrie: "Designing a Multi-Agent Information system for Tele-health", Proceeding of the Second ICSC Symposium on Engineering of Intelligent System(EIS2000) pp.545-548 (2000)